Fish community structure of two Greek close gulfs (Lesvos Island, Aegean Sea)

by

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RÉSUMÉ. - Structure des communautés de poissons de deux golfes enclavés grecs (île de Lesvos, mer Égée).

Les peuplements de poissons de deux golfes de l'île de Lesvos, NE de la mer Égée, ont été étudiés dans 20 stations à l'aide d'une seine de plage. Nos résultats indiquent une relativement faible richesse spécifique (23 espèces). La densité (0,248 individus.m^{-2}, les deux golfes considérés ensemble) et la biomasse (0,343 g.m^{-2}) moyennes n'ont pas été significativement différentes entre les deux golfes. Dans les deux golfes, *Liza aurata* a été l'espèce la plus abondante, suivie par *Sparus aurata* à Kalloni et *Sarpa salpa* à Geras. La distribution des espèces dans les lagunes n'est pas déterminée par le confinement des masses d'eau, en dépit de la vaste surface des golfes et de l'étroitesse du lien entre ceux-ci et la mer ouverte. Inversement, la nature du substrat, la couverture par le macrophytobenthos et l'eutrophisation du milieu pourraient expliquer l'organisation des peuplements de poissons dans ces deux golfes.

Key words. - Fish communities - MED - Aegean Sea - Greece - Confined gulfs - Environmental conditions.

The lagoonal ecosystems, i.e. coastal lagoons *sensu lato* and bahiras (*sensu* Guélorget and Perthuisot, 1992), constitute interesting models for studying distribution of organisms due to their intermediate situation between terrestrial, brackish and truly marine habitats. Irrespective of each particular situation, such kind of ecosystem could be usually characterized by a high productivity, a wide range and a wide variability of hydrographical conditions (current, temperature, salinity, etc.), whereas biological communities are found most often relatively stable over time (Bouchereau *et al*., 2000a). In most situations evoked in the literature, one of the most important factor explaining distribution of organisms within lagoons is the "time of renewal of the elements of marine origin at any given point, and is referred to as confinement" (Guélorget and Perthuisot, 1992).

These ecosystems were widely studied over the world, and fish communities are frequently one of the main focuses possibly due to their socio-economic importance at least at a local or regional scale, in particular in the northwestern Mediterranean (Bouchereau *et al*., 2000a, 2000b). Conversely, the coastal lagoons of the eastern Mediterranean were scarcely studied, although some data already exists on macrofauna (Diapoulis and Bogdanos, 1983; Favry *et al*., 1997) or pollutants (Zenetos and Papathanassiou, 1989; Zanou and Kopke, 2001). The present study was carried out in Lesvos Island (NE Aegean Sea) where the knowledge of fish communities *sensu lato* is inexistent, in marine waters as well as in coastal bays, for pelagic fish as well as for demersal fish. More generally, the ichthyofauna of Greek waters is poorly known, except if one considers some data on species caught by local demersal or pelagic fisheries (Machias *et al*., 2001).

MATERIAL AND METHODS

Two close gulfs were studied in Lesvos Island (39°12'N and 26°17'E) in the northeastern Aegean Sea, both located in the southern coast (Fig. 1). Gulf of Kalloni is about 130 km^2 whereas Gulf of Geras is about 50 km^2. Both gulfs present a narrow channel, which separates them from the open sea, and their maximum depth is slightly higher than 20 m. The salinity within the gulfs could be considered similar to that of the open sea and their variations over time are very low, except in some parts where occur runoffs of often seasonal rivers (Batjakas, unpubl. data). The dynamics of water masses is mainly driven by winds (Millet and Lamy, 2002). Both gulfs are subjected to anthropogenic impacts (mainly N and P inputs), although the amplitude of these phenomenon remains moderate. However, Kalloni could be considered as more affected than

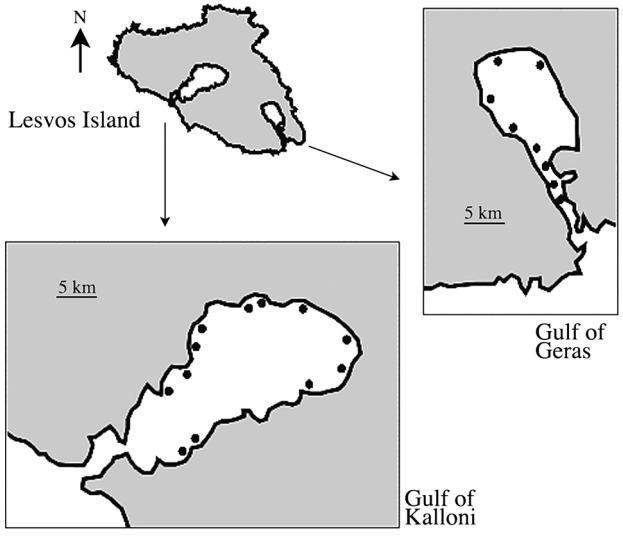

Figure 1. - Location of the two close gulfs studied in Lesvos Island, Greece, and of the stations sampled within each gulf (black dots). *[Emplacement des deux golfes enclavés de l'île de Lesvos, Grèce, et des stations échantillonnées dans chaque golfe (points noirs).]*

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Table I. - Species richness (total, and mean per station), mean density (individuals/m^2), and mean biomass (g/m^2) of the ichthyofauna of the gulfs of Kalloni and Geras, Lesvos Island, Greece. Values into parentheses are standard deviations.: "-"= not statistically tested, "ns"= not significant ($p > 0.05$). *[Richesse en espèces (totale, moyenne et par station), densité moyenne (individus/m^2) et biomasse moyenne (g/m^2) de l'ichthyofaune des golfes de Kalloni et de Geras, île de Lesvos, Grèce. Les valeurs entre parenthèses sont des écart- types. "-" = non examiné statistiquement, "ns" = non significatif ($p > 0.05$).]*

	Kalloni	Geras	Total	SNK-test
No. of stations	12	8	20	-
Total species richness	18	15	23	-
Mean species richness	4.38 (2.22)	5.25 (0.89)	4.71 (1.85)	ns
Mean density	0.211 (0.182)	0.303 (0.184)	0.248 (0.184)	ns
Mean biomass	0.257 (0.166)	0.485 (0.354)	0.343 (0.271)	ns

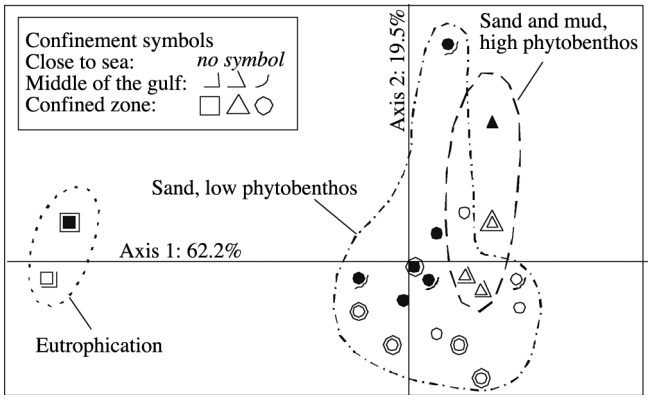

Figure 2. - First factorial plane of the PCA monitored on the density data set. Stations from Geras are in black, those of Kalloni in white. Codes of stations: triangles = stations characterized by sand plus mud, and a high phytobenthos cover ; circles = stations characterized by sand, and a low phytobenthos cover; squares = stations close to a source of eutrophication. *[Premier plan factoriel de l'ACP réalisée à partir des données de densité. Les stations de Geras sont en noir, celles de Kalloni en blanc. Codes des stations : triangles = stations caractérisées par du sable et de la vase, et une couverture haute de phytobenthos ; cercles = stations caractérisées par du sable, et une couverture basse de phytobenthos ; carrés = stations près d'une source d'eutrophisation.]*

Geras, due to the presence of several small towns without any sewage treatment, and a seasonal (December and January) waste of organic matter issued from olive oil factories (Zanou and Kopke, 2001).

Our sampling was carried out in May 2004 with a beach seine (mesh size of 1 cm), in 12 coastal shallow stations in Kalloni and 8 stations in Geras (Fig. 1). Each station sampled covered about 100 m^2. This gear allows a catch of all present species and avoids the selectivity of a fixed gear (Bouchereau *et al*., 2000a). At each station, the nature of the substratum (sand, or sand plus mud), the macrophytobenthos cover, and the proximity of a source of eutrophication were broadly assessed. The whole data set (density of species per station) was analysed with a Principal Component Analysis (PCA) in order to obtain an overview of the organization of the fish communities, whereas the global descriptors (mean species richness, mean density and mean biomass) were compared using SNK-tests.

RESULTS

A total of 23 species, belonging to 11 families, were caught. The three global descriptors (mean species richness, mean density and mean biomass per station) have all shown higher values in Geras than in Kalloni, although the differences between gulfs were not significant (Tab. I). Species richness varied from 4 to 6 species per station in Geras, and from 2 to 9 in Kalloni, but without any clear link with the distance to the open sea-gulf channel. A similar absence of trend was found for the distribution of density and biomass in relation with the distance to the open sea-gulf channel.

In both gulfs, the most abundant species was *Liza aurata* (0.116 ± 0.196 individuals.m^{-2} in Kalloni, and 0.123 ± 0.172 individuals.m^{-2} in Geras), followed by *Sarpa salpa* (0.090 ± 0.112) and *Gobius cobitis* (0.064 ± 0.052) in Geras, and by *Sparus aurata* (0.078 ± 0.128), *S. salpa* (0.063 ± 0.038) and *Symphodus cinereus* (0.041 ± 0.036) in Kalloni.

The first factorial plane of the PCA revealed that the fish communities of the stations sampled are not primarily organized according to the confinement, i.e., to the distance to the open sea-gulf channel (Fig. 2). Axis one of the PCA clearly distinguished the stations close to sources of eutrophication and freshwater inputs from the other ones, and, in addition, allowed to highlighted the role of the nature of substratum and the macrophytobenthos cover (Fig. 2). Axis two allowed to separate the fish composition from both gulfs. Globally, *Liza aurata* characterised the eutrophized stations, *Sparus aurata* sandy stations with a low macrophytobenthos cover, and *Sarpa salpa* and *Symphodus cinereus* sandy – or sand plus mud – stations with a moderate to high macrophytobenthos cover.

DISCUSSION

Although our findings are preliminary, and should be considered with some caution, it appeared that environmental parameters such as macrophytobenthos cover, substrate characteristics and proximity of an eutrophication source are more important in explaining fish distribution than distance to the open sea-gulf channel in the two gulfs of Lesvos Island. Some authors, considering hydrological data in Gulf of Kalloni, also concluded that this gulf was not characterized by the confinement of water masses, probably due to a good turn-over of water masses driven by wind patterns (Millet and Lamy, 2002). Our results on fish fauna support this view. We suggest that fish communities of both gulfs are distributed in relation to substrate and environmental variables rather than according to an increasing degree of isolation from the open sea, despite the relatively high distance between the channel and the "opposed part" of the gulf (e.g., 13 km in Geras, and 25 km in Kalloni) and the narrowness of this channel. In addition, we also observed numerous echinoderms (mainly *Paracentrotus lividus, Arbacia lixula*, and/or *Holothuria* spp.) in most of the stations sampled, whereas the disappearance of this phylum within a lagoon *sensu lato* is considered as the transition between zones II and III (*sensu* Guélorget and Perthuisot, 1992), which are both weakly confined zones. Such a spatial pattern was also found in other Med-

iterranean lagoons, in which confinement appeared low to moderate such as in Nador, Morocco (Bouchereau *et al*., 2000b). Conversely, in most lagoons organized according to a real confinement of water masses, species richness, density and biomass most often decreased with the increase of the distance to the open sea-lagoon channel (Guélorget and Perthuisot, 1992; Bouchereau *et al*., 2000a, 2000b).

Finally, ecological consideration such as feeding habits and habitat preferences of the most abundant fish species might be the most appropriate explanations to our results. *Liza aurata* is a widely distributed species in the Mediterranean and its abundance in eutrophized stations could be related to its omnivorous and opportunistic diet (Ben-Tuvia, 1986). *Sparus aurata* could be found on rocky coasts and seagrass beds, but is usually more abundant on "mixed" habitats, i.e., sandy-rocky bottom with patches of macrophytes and/or seagrass beds as it was the case in our results (Francour, 1990). The abundance of *Sarpa salpa* and, to a lower extend, of *Symphodus cinereus* could be related to the macrophytobenthos cover and the sandy bottom. The former is a well known herbivorous species (Verlaque, 1990) and is logically more abundant in places where macrophytobenthos cover is well developed. The latter species is a small carnivorous, feeding on benthic invertebrates, and is often found on sandy bottoms close to macrophytes as it use algal fragments for reproductive purposes (Lejeune, 1985). Further research is needed in order to improve the knowledge of the ichthyofauna of Greek coastal waters, and the two gulfs of Lesvos Island could be good places for such a purpose due to the relative calm hydrodynamic conditions and existing data set on other compartments, i.e. pollutants and macrozoo- and macrophytobenthos.

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